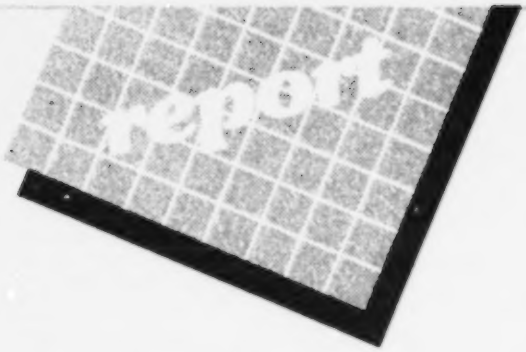

Techniques For The Construction Of Small Dams In Small Streams

October 1983

By

Gilles Paquet

Québec

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NOTES

1- Certain illustrations found in this booklet have been adapted from other publications.

Sources: Candy, R. 1964. Some construction hints for stream improvement work. Vermont Fish and Game Department, I and E Division. Pamphlet, 4 pp.

United States Department of the Interior Bureau of Land Management, 1968. Stream preservation and improvement, B.L.M. Manual 08-22-68.

United States Department of Agriculture, Forest Service, 1952. Fish Stream Improvement Handbook. U.S. Printing Office, 1952, 0-232379.

White, R.J. and O.M. Brynildson. 1967. Guidelines for management of trout stream habitat in Wisconsin. Department of Natural Resources Technical bulletin No. 39. 65 pp.

2- None of the authors consulted are mentioned in the text, thereby simplifying its structure and making it easier to understand for the largest number of readers. In addition to the author's own ideas this booklet reflects a synthesis of the ideas, experiments, observations, remarks, recommendations and suggestions of the various authors consulted.

INTRODUCTION

All too often man in his continuous quest for progress and development has shown little concern for the conservation and welfare of wildlife.

It is well known that man's activities have resulted in the extensive destruction of aquatic and terrestrial habitats. The drainage of swamps, channelization and straightening of streams, excessive forest cutting encroachment, silting up, erosion and pollution continue to be major factors contribution to the destruction of aquatic habitats.

On the other hand, man according to his abilities and will, can intervene and take steps that may be beneficial to wildlife.

We can correct or improve many natural or dangerous situations requiring specific intervention by way of a few simple physical means.

This booklet is intented as a practical tool to encourage and help people to become more interested in the beneficial effects of human intervention in various aquatic habitats and in particular in small streams.

The reader is advised to consult the glossary at the end of this booklet for it is there that many of the terms and expressions used in the text are defined.

ECOLOGY NOTIONS

General remarks

In the past it was commonly believed that all that fish required to survive was water and a little food. We now know that fish have many other requirements when it comes to their habitat and conditions of life.

For example, according to the type of species of fish, the water they live in must be of a certain temperature and chemical composition. To ensure proper growth food must be readily available in sufficient quan-

tity and of appropriate quatily. There must be a sufficient number of spawning areas in appropriate locations to maintain natural reproduction. In addition certain species will only live or reproduce in areas where there is shelter nearby where they can hide.

Each group of animal species has specific environmental requirements, whether it be aquatic insects, crustaceans (crayfish) or amphibia (frogs and salamanders) which are also found in streams.

A stream with its fish, insects and aquatic and riparian vegetation constitutes a living environment which is constantly changing and whose resources are beyond compare.

BASIC PRINCIPLES

A number of basic definitions are given in the next two pages and it is of the utmost importance to understand their meaning. These basic principles must be mastered if the reader is to logically apply the intervention techniques and methods.

Basic elements for life

We mentioned earlier that each species has its own specific environmental requirements. We shall now try to simplify and summarize them in six main points:

- food;
- water;
- shelter;
- reproduction areas;
- vital space for survival (territory);
- ready access to each of these elements.

The habitat

The specific proportion or arrangement of the above-mentioned factors constitutes the habitat of a given species, whether it be for insects,

fish, birds or other.

The carrying capacity

The quantity, quality and distribution of these basic factors in the habitat, as well as the social system of the species in question will determine how many members of the species can be supported by the habitat at a given moment. This relation is generally known as the carrying capacity of the habitat.

The food chain

The various forms of life in streams are complicated and are dependent on one another. In very small streams (springs) life is dependent first of all upon the presence of organic matter such as fallen leaves and tree trunks and branches, which have fallen naturally or as a result of man's acts.

Some forms of aquatic insects (larvae) feed on leaves transformed in a few weeks by microscopic fungi whereas others may feed on wood debris transformed after several months by other phenomena. These insects along with a small amount of microscopic aquatic vegetation make up the first links of the food chain.

The transformations brought about by these first groups of organisms are but the beginning of a long process which becomes more pronounced and complicated as we go downstream. It is here that more numerous and complex forms of aquatic life take advantage of these same transformations, which as we stated continue to develop and grow more complex as we go downstream.

The importance (if not the complexity) and the role of the food chain also depend on the physical nature of the streams, their size, their order in the watershed(s), their geographic location and necessarily the general state of the environment.

The role of riparian vegetation is of prime importance in the development and maintenance of food chains in streams, as well as in the deve-

lopment and maintenance of the configuration(form) of these streams. An important part of the fish's diet over the various seasons is made up of "land-based" insects which have fallen from plants growing on the banks. In this way riparian vegetation plays as important a role as aquatic vegetation. In addition riparian vegetation is very important for the survival of a large number of other animals, such as furbearer animals, nongame birds, waterfowl, big and small game, amplibians, reptiles and many others.

Improvement and/or restoration (definition)

Most of the environment improvement projects that we can carry out are in reality restoration; i.e. the correction of natural deficiencies or deficiencies causes by or resulting from human intervention. However, it should be recalled that whatever the improvement project, we must always take care to apply the basic principles of ecology that were mentioned earlier. Our interventions may be defined in the following manner:

The improvement and restoration of aquatic habitats (lakes or streams) consists in manipulating the vegetal, chemical and physical qualities of these habitats in order to create and maintain conditions which are more favourable to the survival, growth and reproduction of one or several animal species such as fish.

PRACTICAL CONSIDERATIONS

Importance of appraisal

Witnout a preliminary overall appraisal, we run the risk of causing more harm than good in our efforts to restore a stream.

The abundant and varied resources of aquatic and riparian habitats dictate that we examine the stream as a whole and not just an isolated section before any intervention. This will enable us to better identify the real problems, to situate them in time and space, in order to note their extent and to make a wise choice of remedies, interventions and

improvements which are both necessary and feasible. However, it must be remembered that each stream or group of streams poses a particular set of problems.

Procedures

It is of the utmost importance to have an expert's opinion, if we are to correctly identify the nature, extent and location of problems or deficiencies, as well as the relative importance of the latter in relation to the stream (s) as a whole. We may invite an expert to visit the area in question or consult him with the data on hand.

A plan or sketch of the project (s) may be made. To this we may add intervention priorities, methods to be used according to the type of problem, nature and amount of materials required and necessary manpower where applicable. All these elements come under the heading "procedures".

If we wish to tackle the problems of one or more streams, or of one or more sectors of a stream in a logical and comprehensive manner, it is prudent to always start upstream and proceed downstream.

Even if we wish or are able to intervene for several animal species at a time, it is preferable to use intevention methods which are easily applied and relatively efficient. From the outset it is better to insist more on the quality of the intervention methods than on the quantity of interventions.

We should also like to emphasize that the improvement and restoration of aquatic habitats also require a whole series of observations, inspections, trials and tests which require a great deal of patience. The success of the interventions and achievements must always remain a prime concern.

We suggest that a stream be observed for a full one-year period before any intervention is undertaken. A strict minimum would consist of making observations during the spring when the snow melts and during heavy

rains, during the month of July (low water) and in the fall when it also rains heavily.

Preoccupations

Streams ranging from the smallest sources to small rivers approximately 8 metres in width (25 ft.) should be the object of our main preoccupations to restore riparian and aquatic habitats in streams.

It should be noted that streams, whatever their size and this is particularly true for Quebec, are dynamic and unstable systems; i.e. structures whose components (banks, waterflow, pools, meanders, rocks, vegetation, etc...) may be altered, moved, changed among other things by floods and ice. Taking these facts into account, our interventions must be carried out in a manner so as not to increase or alter in general the dynamics and instability of our streams, otherwise we risk to disturb acertain natural balance that exists in the streams, habitats and animal populations that we intend to restore. In other words, we must not act in such a manner as to make worse those environment or habitat conditions that are judged as needing to be improved or changed.

Warning

Any individual or organization wishing to carry out any construction project whatsoever in a lake or stream should first of all take into account a few precautions concerning certain laws and/or regulations dealing with public and private land.

First of all we should mention that the ministère de l'Environnement du Québec administers and enforces the Environment Quality Act and the Watercourses Act, whereas the ministère de l'Energie et des Ressources administers and enforces the Lands and Forests Act.

It is provided for in section 22 of the Environment Quality Act that no one may erect or alter a structure, if it seems likely that this will result in a change in the quality of the environment unless he obtains from the Director a certificate of authorization.

The word "director" refers to the Regional Director of the ministère de l'Environnement; this position will soon be created.

We should also mention that the ministère de l'Environnement permits the construction of dams or dikes less than one metre (38 inches) in height without requiring that the plans and specifications be subject to approval as stipulated in the Watercourses Act.

In addition, the regulation concerning the enforcement of section 2 of the Watercourses Act does not permit works resulting in encroachment (fill) on the bed of a public watercourse.

The methods and norms presented in this guide are in line with the forementioned laws.

A- On public lands

With regard to the felling of trees necessary for the construction of one or more dams or cribs on streams in public forests (crown lands), it is necessary to obtain prior authorization from the ministère de l'Energie et des Ressources.

This holds true both for an application made by an individual or a group of individuals. The latter will have to make their application and give a detailed description to the M.E.R. (Mines, Energy and Resources) director in charge of forestry management in the region in question. If judged acceptable, the felling permit will be granted after a certain time period (a few weeks) according to the conditions specified in the Lands and Forests Act and the regulations dealing with woods and forests. The individual or group of individuals should expect to have to pay felling rights.

Departments other than the ministère de l'Energie et Ressources, as well as all other government and parapublic offices and agencies must also obtain a felling permit, but do not have to pay any fees.

B- On private lands

For our purposes private lands may be considered as those being part of any municipality or municipal corporation and/or former seigniory.

A large number of interventions carried out or which may be carried out on private and municipal lands are governed by the Municipal Code and/or the Cities and Towns Act (ministère des Affaires municipales).

Any individual or group of individuals wishing to intervene on these lands should obtain the consent of the municipality or municipal corporation where the stream is located, as well as that of all the landowners along the stream who might be affected by the intervention project.

It also must be remembered that the ministère de l'Environnement du Québec also administers the Tree Protection Act which stipulates that it is prohibited to destroy or damage either wholly or in part a tree, sapling or shrub or any brushwood unless consent has been given by the owner of such a tree, sapling, shrub or brushwood. This act also applies to public lands.

Finally, it would be preferable if the individual or group of individuals wishing to intervene on public, municipal or private lands were to consult the biologists of the ministère du Loisir, de la Chasse et de la Pêche of the region in question on this matter.

Groups or individuals interested in improving streams should first of all learn about the abundance, behaviour and requirements (natural history) of the species affected by these interventions before taking any action.

ACTUAL INTERVENTION METHODS

Objectives and customary precautions

With these first considerations in mind, let us now take a look at a few improvements or adjustments that can be carried out in streams.

The proposed methods are taken from works or based on ideas generally dealing with brooks and streams where trout can be found. However, we feel that other species such as smallmouth bass, rock bass, fallfish and yellow perch could profit from these same improvements carried out in streams and brooks where the water is generally warmer during the fishing season and where seasonal floods are generally greater, more frequent and more sudden.

The improvement techniques or methods proposed in this booklet concern the construction of dams leading to the formation of pools particularly below the latter.

Objectives

Retoration and improvement methods must aim at attaining certain objectives such as:

- To maintain, improve or restore the environmental conditions of the stream in question in the best possible state so as to ensure the propogation and survival of the target species;

- To maintain or improve water quality to a level compatible with the species or popultions in question;

- To construct and locate spawning sites so that there is sufficient natural production to supply as many fish as the stream may support;

- To provide sufficient cover of a varied nature to shelter as many fish of varying age as the stream can properly support;

- To develop or improve food productivity to improve the productivity and growth of fish;

- To prevent bank and streambed erosion;

- To facilitate the circulation of fish from one stream to another or from one stream sector to another;

- To maintain a balance between the various conditions of the environment. To not overdevelop one factor without taking into account the effects on the others. E.g. To not develop too many spawning sites if there is not enough food for all of them or enough shelter;

- To provide better opportunities to improve, maintain and develop recreational fishing in the stream;

- To take into account all the wildlife species likely to be affected by these interventions and to promote their development if possible.

PRECAUTIONS AT THE TIME OF INTERVENTION

To respect the asthetic value of the environment, it is preferable to use whenever possible natural materials found in the area for the realization of any projects. These materials may include logs, coniferous branches, gravel, rocks, tree trunks, etc...

The removal of materials from the site must be done in such a manner as not to alter or modify conditions which are already favourable for one or more of the animal species affected directly or indirectly by the work projects.

Stream projects must not be carried out during the reproduction period or the fish egg hatching period. For streams where there are trout it is preferable to carry out work between May 1st and August 15th, whereas for streams with other species of fish, it is better to do the planned work between July 1st and December 1st.

To further reduce any risks of damaging the environment the use of heavy machinery should be avoided with the emphasis on using as much manual labour as possible when carrying out projects. In addition, the natural materials needed for the project should be collected from as many different areas as possible.

All these precautions in addition to the actual construction work require a great deal of time. This should be taken into consideration when the plans and projects are being prepared.

DAMS/SILLS

One of the most important factors which can improve the survival, permit better growth, increase the concentration and improve fishing of certain fish species is the presence of pools in a stream. Moreover, pools provide excellent shelter for fish. Very often large quantities of gravel deposit downstream of these pools and serve as spawning sites for several species of fish.

The majority of North American authors and specialists recommend that a stream be improved by using small dams to the point where 50% of the stream be made up of pools (both natural and man-made) and 50% be made up of riffles. This would present ideal conditions for trout for example.

In the pools fish can hide and rest, whereas in the riffles they can feed on either fish, insects or algae clinging to the rocks or gravel, or even food floating with the current.

This ideal proportion of pools and riffles, which respects existing natural pools seems to be feasible in regions where fall and spring floods are minimal and do not occur suddenly, which does not seem to be the case in Quebec generally.

On the other hand, it is common knowledge that a stream where there are both pools and riffles has a slower flow and cleaner water than a drainage channel. However, this method still remains useful and must be adapted to our needs and the environmental conditions fo the stream if we are to use it.

Sills are generally small dams, dikes or "pool diggers" intended to create a small waterfall which will result in depressions in the stream bed at the foot of the sills. This digging action by the water frees gravel from between the large rocks that usually remain in place. The gravel thus freed is generally carried by the current and most of the time a large portion or quantity of this gravel is deposited downstream of these pools. These pools must be of a permanent nature and must be such that fish can live and reproduce there. It is also important that the fish be able to surmount the sills if the behaviour of the fish species requires it.

The implantation of small dams leads to a rise in the water level on the dams and upstream of the dams (over a certain distance) both in low water periods and even more so in flood periods. It may happen that in the case of certain streams or certain sections of the streams, the presence of sills causes bank erosion at the ends of the sills and a little upstream and downstream from these points. Bank erosion is a problem which must be avoided if we are to conserve the quality of our streams. In the section dealing with the actual methods we will see how to avoid bank erosion around the ends of the sills.

ESSENTIAL CONSIDERATIONS FOR THE CHOICE OF SITES

Several aspects and factors should be considered when choosing a site for the construction of one or several sills. We should:

- Have a fairly good idea of the extent of seasonal floods (low and high water;

- know the potential or actual spawning sites of the various species of fish in question and not alter them;

- choose a fairly straight, flat and uniform stream or stream section which is shallow during low water periods (low water, drought, two to six inches) generally between the end of June and the end of July;

- choose a sector where the stream bed is made up of a thick mixture of rocks, sand and gravel at least twice the height of the sill;

- choose one or more sections where the slope of the streambed does not exceed 3%;

- avoid constructing sills in a section where the slope is too slight;

- not alter natural pools;

- ensure that the banks at each end have a slope of at least 45° beforehand in order to avoid overflows;

- ensure that the banks are high enough above the stream (in this case a vertical line); i.e.:

  - approximately 0.75 to 1.3 metres in height for the banks of a stream 1.66 to 3.3 metres in width;

  - approximately 1.3 to 2.5 metres in height for banks of a stream 3.1 to 8.0 metres in width.

- choose places where the banks are composed of stable materials such as shrublike vegetation (alders, sweet gale, willows, etc...), solid rocks, stones, tree roots, various plants, ect...;

- not build a dam near or on banks which are too eroded or which lack vegetation unless there is a lot of material available to protect them from erosion;

- take advantage of natural phenomena such as the presence of nearby forests (coniferous ones especially), availability of large stones,

presence of very large or oblong rocks and gravel which is dry during low-water periods;

- use coniferous wood in particular when building dams;

- build in such a way as the main portion (if not all) of the sill structure is submerged (flooded) to prevent the wood from rotting;

- in the case of trout supporting streams build sills in such a way as not to restrict or slow down the flow of water too much in order to avoid heating up the water;

- not build a dam too close to a tributary whether it be a spring or a brook. During floods the flow of these small streams will add to the flow of the main stream and may cause turbulence or alter the sill or the bank at each end of the latter;

- not build sills closer than 22 m(75 ft) together when the streams are between 3 nd 8 m (10 to 25 ft) in width. The rule should be to separate small dams from a distance equal to five (5) to seven (7) times the avarage width of the section of stream to be improved;

- be on the guard against the presence of beaver in the sector in question;

- as a minimum precaution always consult the biologist responsible for the area in question before commencing work.

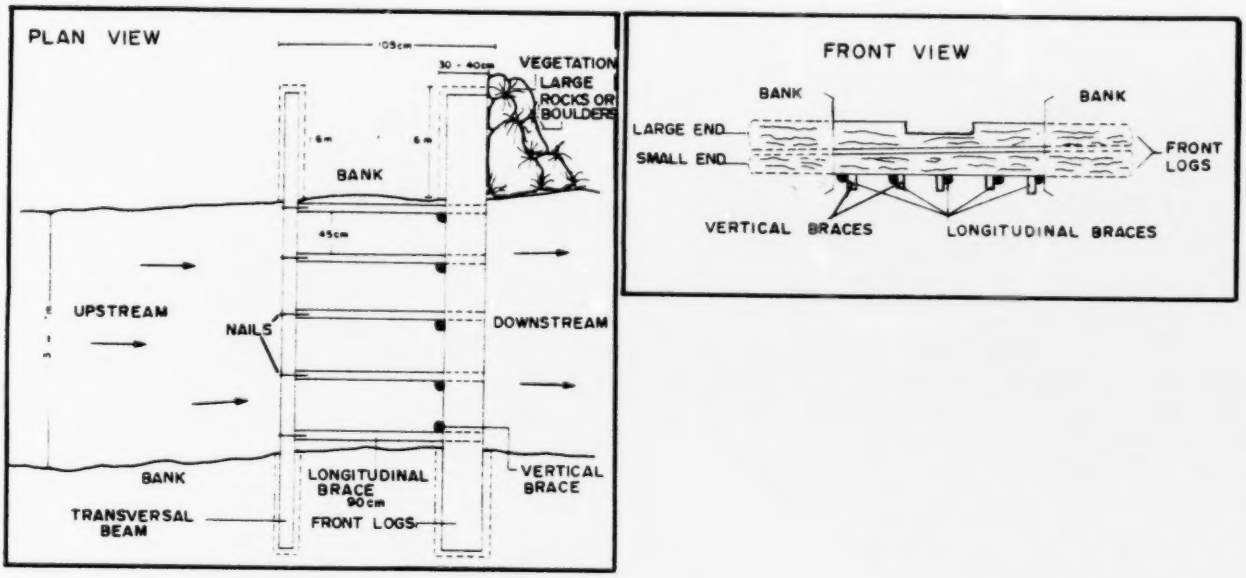
Following these important considerations which must be taken into account, we would like to describe the techniques for building dams which we feel are practical, resistant and relatively easy to carry out.

Certain methods may seem somewhat similar, but the differences although sometimes very subtle are worth dwelling upon and should be applied.

A- TWO-LOG PLANK DAM

For streams or sections of a stream 3 to 8 m in width on the average, we suggest building two-log plank dams. This method may also be used for narrower streams up to around 1.6 m in width; naturally the proportions must be modified accordingly.

First step: Levelling the streambed and digging the banks



When the site for a given sill is chosen, the streambed is prepared over a length of 105 cm (42 in.) from one side to the other by levelling the latter out as best as possible without upsetting the whole environment.

The gravel, rocks and sand are arranged in such a way as to support a level framework.

At the upstream and downstream limit of the levelled site, holes are dug in the banks measuring 30 to 40 cm (12 to 16 in.) in width and 1.6 m (5 ft) in depth. These holes which will eventually house tree trunks must be made by shovel if at all possible, unless there are major difficulties necessitating mechanical means.

If the logs are supported by large boulders it is not necessary to drive them 1.6 m into the bank; a hole 1 metre in depth is sufficient.

The two superposed logs must not constitute an obstacle more than 30 cm (12 in.) in height and care must be taken to ensure that they are placed as horizontally level as possible from one end to the other.

Once the two logs and beam are in place, the open space around the log ends in the bank must be sealed, if not filled and plugged.

A number of materials may be used to do this including the material removed when digging the holes in the bank, as well as any number of mixtures of tree leaves, gravel, sand, sludge and moss which seal these spaces well to prevent water from circulating freely. All of this must then be covered with resistant material that we will describe further on.

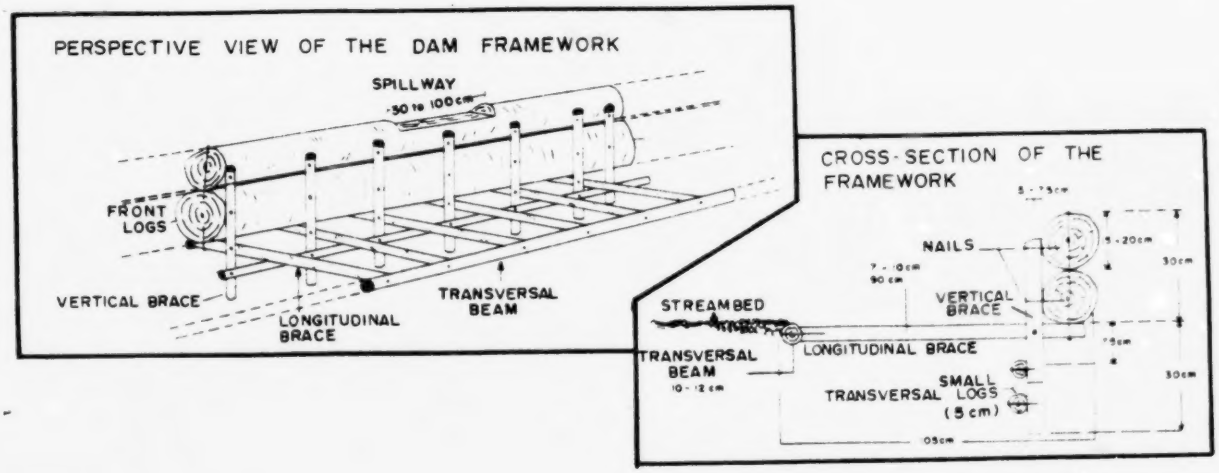
Another operation is necessary to complete the supporting framework.

On the upstream side of the sill, pieces of coniferous wood 5.0 to 7.5 cm (2 to 3 in.) in diameter are nailed vertically to the two front logs and are also separated 45 cm (18 in.) apart center to center.

At upper end, each of these pieces of wood should not extend beyond the centre of the upper log where they are nailed. The bottom end of these pieces of wood should exceed the bottom log by at least 7.5 cm (3 in.). They are also nailed to the centre of the lower log and laterally (on the side) to the parallel longitudinal braces. These vertical braces may even exceed the lower log by 30 cm (12 in.); on the upstream side two small transversal logs may be nailed to the vertical braces and extending from one bank to the other.

This last section of the framework is not indispensable but may in certain cases help keep the materials on which the two logs are supported in place for a longer period.

Second step: Supporting framework



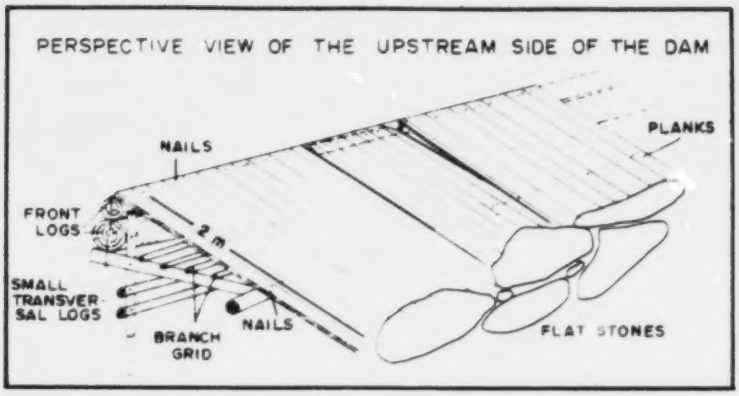
Upstream at the limit of the site a transversal beam 10 to 12 cm (4.5 in.) in diameter is lodged transversally in the streambed and driven 1.6 m (5 ft.) into the bank on each side. The top of this beam must be at the same level as the streambed surface.

Longitudinal braces 7 to 10 cm (3 to 4 in.) in diameter and 90 cm (36 in.) in length are placed on the streambed parallel to the direction of the current. The upstream end is placed against and nailed perpendicularly to the transversal beam. The longitudinal braces are fixed 45 cm (18 in.) apart center to center.

Two coniferous logs 15 to 20 cm (6 to 8 in.) in diameter are placed on the downstream end of the parallel logitudinal braces. The logs are piled one on top of another with the small end on top of the large end and are driven 1.6 m (5 ft.) into the banks at the designated locations. These logs are held in place by 25 to 30 cm (10 to 12 in.) spikes.

The two superposed logs may also be placed against large boulders which are solidly anchored in the banks instead of being driven into the latter. They also may be supported by boulders and at the same time bedriven into the banks. This latter method is the most practical.

Third step: Construction of the upstream side of the dam.



Dig a hole in the streambed on the upstream side of the transversal beam. The hole should be 1 m in width and from 0 to 30 cm (12 in.) in depth following the angle of the sill, but inversely.

The material thus removed should be kept and place nearby.

To build the upstream side of the dam, softwood planks (fir, spruce, larch, etc...) are used. They must all have the same length and thickness; i.e. 2 m in length and at least 3.75 cm (1.5 in.) thick. The width may differ if necessary.

The planks are first nailed on the upper log of the dam, but no higher than the top and then on the transversal beam.

The end planks should be driven into the banks when possible (half of their width sould suffice); if this is not possible they should be placed as near as possible to the bank. It is of the utmost importance that no water filter into the bank.

As the planks are placed and nailed as close together as possible, any space there might be under the planks upstream of the transversal brace

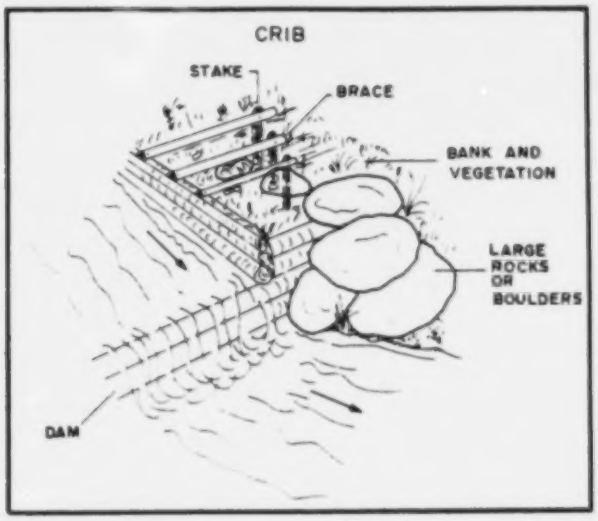
is filled with part of the material removed while digging. The rest of the material starting with the sand and gravel is placed on the plank floor in order to completely fill the hole that was dug. Afterwords it is preferable to cover everything with flat stones or coarse gravel to offer better resistance to the current.

Before placing and nailing the planks, it is also possible to fill the space between the upper part of the plank floor and the longitudinal braces, if the necessary mterials are available in sufficient quantities and are nearby. To do so a fir branch grid is attached alongside the superposed front logs and on the longitudinal braces. This space is then filled with gravel and sand. This type of fill may offer a better "watertightness", better support for the dam planks and might reduce scouring risks under the dam by reducing water infiltration.

However, all this is not absolutely necessary to obtain good results with this type of dam.

The layout of the plankfoor and the supporting structure forms an angle of around 20°. According to some specialists this angle of the layout offers the best resistance to water pressure when there are major floods.

Fourth step: bank protection at each end of the dam



During floods (high water conditions) water and ice may erode the bank at each end of the dam. To prevent some damage the two banks may be covered with large flat or oblong stones. Stones would have to be placed over a length of 1.6 m (5 ft.) upstream and downstream of each end of the dam and should be as high as the spring flood line. A little gravel, sand or dirt is placed between the stones in order to grow clumps of grass, couch grass or any other plants that will take root and grow rapidly on the bank. Any other material of a natural appearance can be used to carry out this work.

The method which seems to be the most efficient for protecting the bank around each end of the dam is the construction of cribs which requires an inspection visit each spring.

Each crib is built in the following manner:

- The first log (cedar, fir, larch) 4 m in length (13 ft) and 20 cm in diameter (8 in.) is nailed on the dam 15 cm (6 in.) from the end this

log is mortised and attached to the dam, whereas on the upstream end the log is pressed horizintally against the bank.

- A second log of the same dimensions is nailed or attached on top of the other and is arranged in the same manner. Three or four braces are then mortised or nailed to the upper log and then nailed to a stake which has been driven 1 m (38 in.) into the bank.

- The space between the lower log and the plankfloor is filled with a mixture of dead leaves, gravel, moss and sand. On top of all of this oblong stones are tightly placed.

- After this is done, the empty space between the logs and the bank is filled with gravel, moss, rocks and sand up to the surface of the braces. At the downstream edge care must be taken to install a large boulder or piece of wood to keep this fill in place. Flat or oblog stones weighing up to 150 kg (300 lb) are placed on this fill. Enough stones should be placed to ensure that the crib is at least 1 m in height (38 in.).

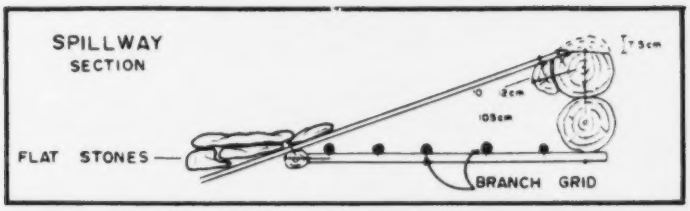
- Since this type of crib is not always under water, it may begin to rot after a few years.

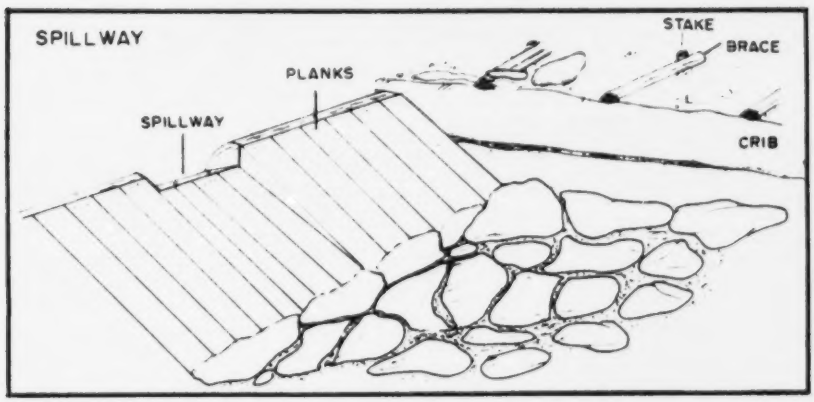
- If possible treated wood (non-toxic), white cedar or stripped larch should be used.

- This type of crib construction helps maintain dams in place, regularize waterflow on the latter and increase the digging action of water.

- The same type of crib can be built on the downstream side of the dam ends, but it would have to be smaller. Cribs 2 metres in length would be sufficient.

Fifth step: cutting out a spillway





If we wish to cut out a spillway for this type of dam, (8 meters) we must be able to place planks in front the spillway and lower than the rest of the plankfoor.

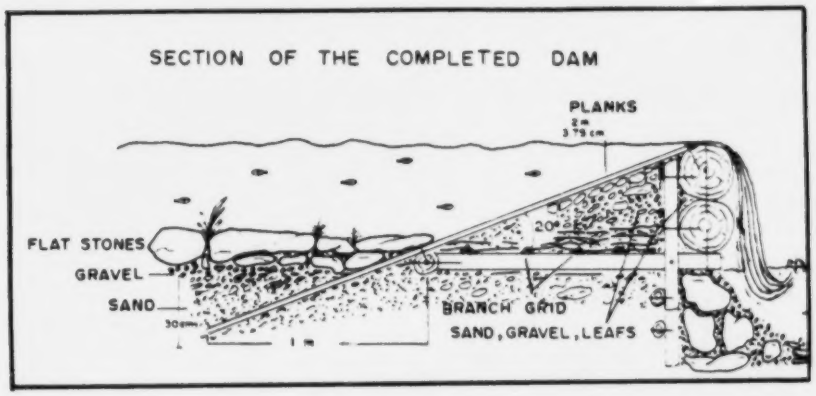
First of all a groove 7.5 cm (3 in.) deep and 75 cm (30 in.) long must be made in the centre of the upper log.

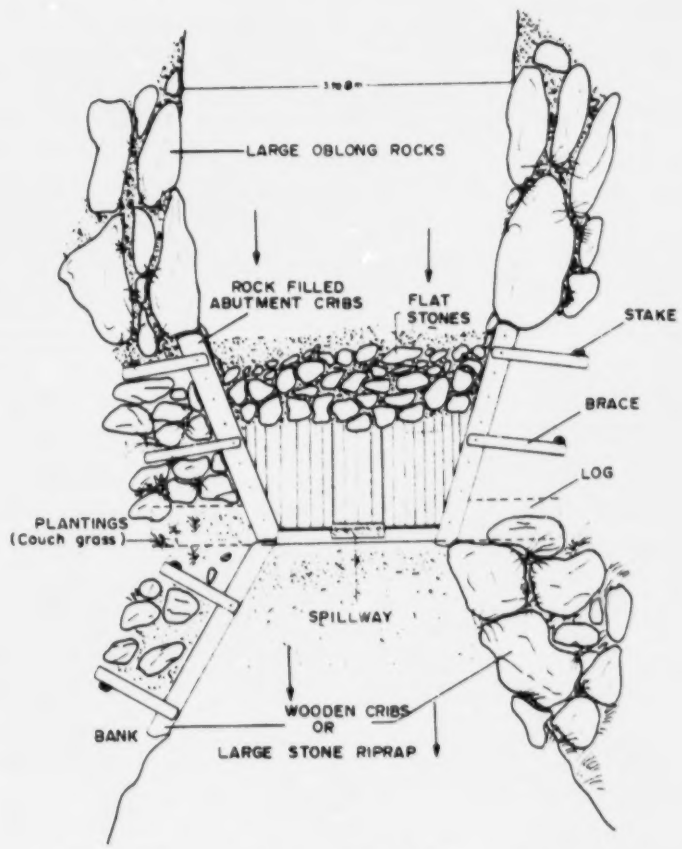
A piece of wood 10 to 12.5 cm (4 to 5 in.) in diameter and 105 cm (42 in.) in length is then attached to the side of the trunk opposite the groove. The top of this piece must placed at an equal level to the groove base. The front (downstream side) of this board must be flatten by one fifth to one quarter of its width and then be nailed in place with 12.5 to 15 cm (5 to 6 in.) nails.

The planks will be nailed to this piece of wood in the same manner as the others are nailed to the rest of the dam.

The open space between the planks of the actual dam and the planks fastened to the spillway, will have to be sealed with a plank in the form of an allongated triangle; this form is the most appropriate.

The dimensions just mentioned for the cutting of a spillway should be ajusted to different sizes of dams.



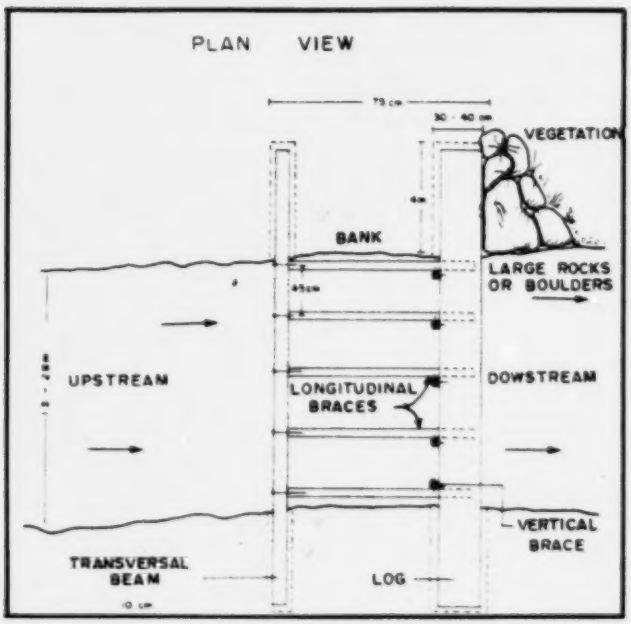


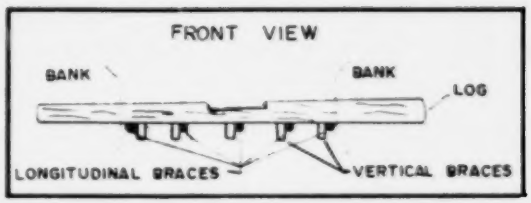
PLAN VIEW OF THE COMPLETED DAM

B- SINGLE LOG PLANK DAM

The same type of dam as described earlier can be used for streams measuring 1.33 to 2.9 m (5.0 to 9.5 ft.) in width but using a single log; all we must do is change the proportions.

Levelling the streambed and excavating the banks

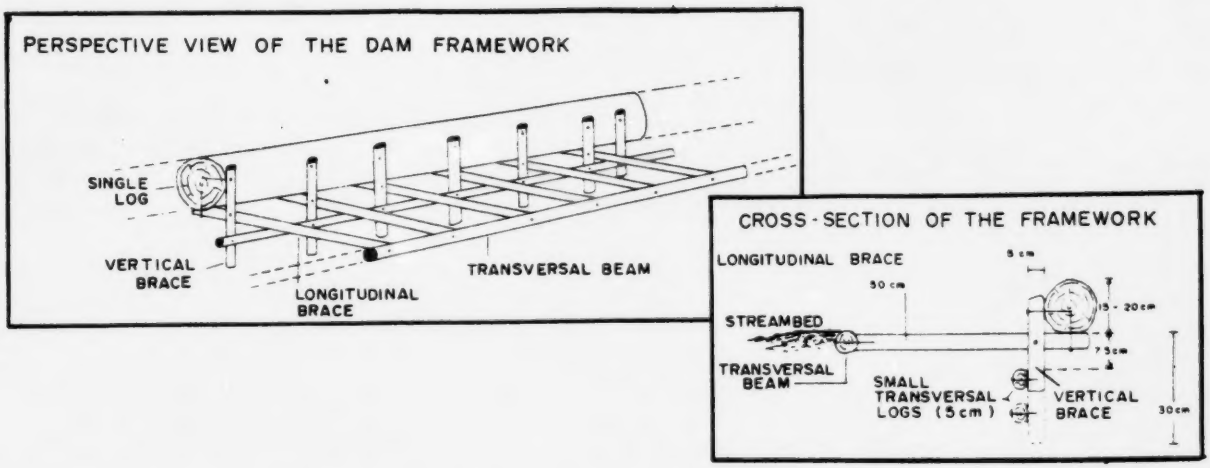




The chosen site is prepared the same way as described in the preceding method. The streambed is manually levelled from one side to the other over a width of 75 cm (30 in.) taking care to make it as level as possible without upsetting the environment.

At the upstream and downstream limits of this site, holes are dug into the banks horizontally. They should be 30 to 40 cm (12 to 16 in.) in width and 1.4 m in depth (4 ft.).

Supporting framework



A transversal beam 10 cm (4 in.) in diameter is lodged into the bed and driven into the banks at the upstream limit of the prepared site.

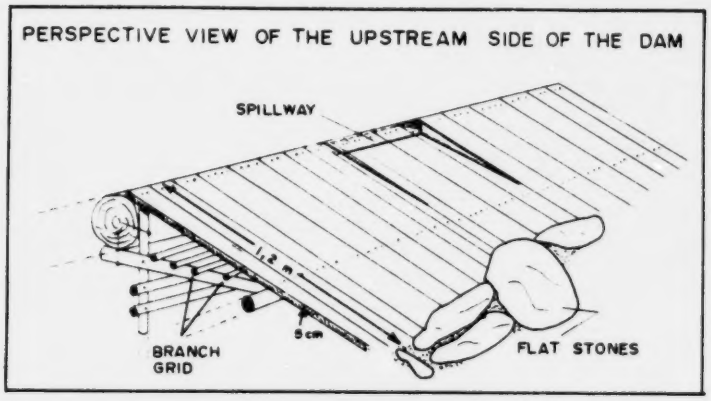
Parallel longitudinal braces 5 cm (2 in.) in diameter and 50 cm (20 in.) in length are supported perpendicularly against and nailed to the downstream side of the transversal beam. These longitudinal braces are placed 45 cm (18 in.) apart center to center.

A single log measuring 15 to 20 cm in diameter is placed on the other end of the parallel longitudinal braces. The log ends are driven 1.2 m (4 ft.) into ;the banks at the locations indicated.

Pieces of wood 5 cm (2 in.) in diameter are nailed vertically to the upstream side of this log. The upper end of these pieces should hardly exceed the centre of the log and it is here that they are nailed. The bottom of the log and are laterally nailed to parallel longitudinal braces that are attached to the transversal beam.

In this case like in the preceding one, the vertical braces may exceed the log base by approximately 30 cm (12 in.). One or two small transversal logs extending from one bank to the other could be nailed to each vertical brace on the upstream side.

Upstream side of the single log plank dam

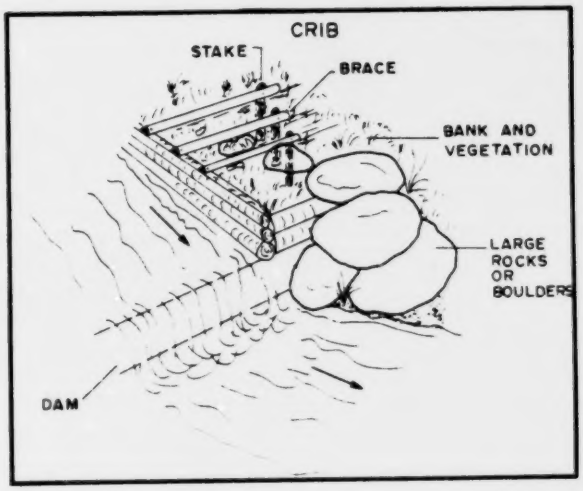


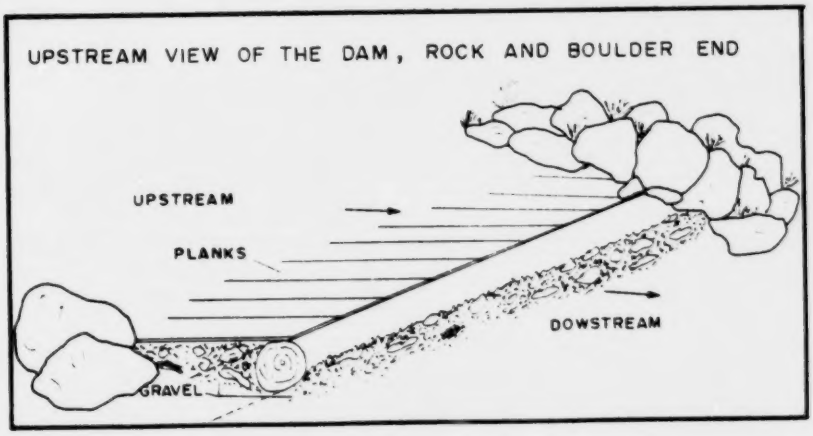
The same methods described for the first type of plank dam are used to build the plank floor and to protect the dam ends.

The plankfloor will also be made of softwood planks (fir, larch, spruce, etc...) 3.75 cm (1.5 in.) thick and 120 cm (4 ft.) long.

The ends

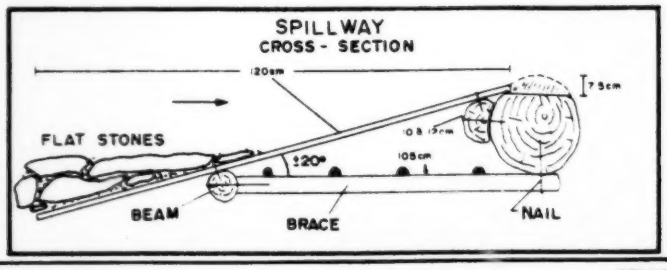
Around the dam ends we should place piles of rocks mixed with clumps of grass and couch grass or we also can build cribs like those described and illustrated in the preceding method.

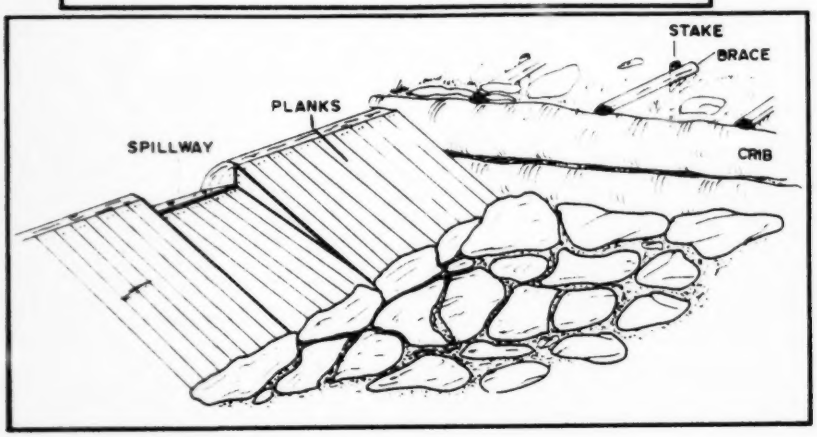




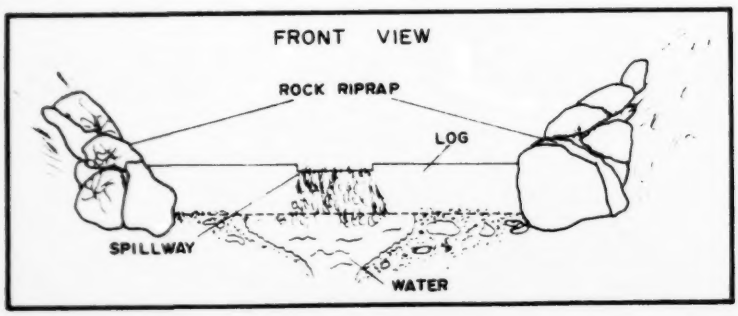
Cutting out the spillway

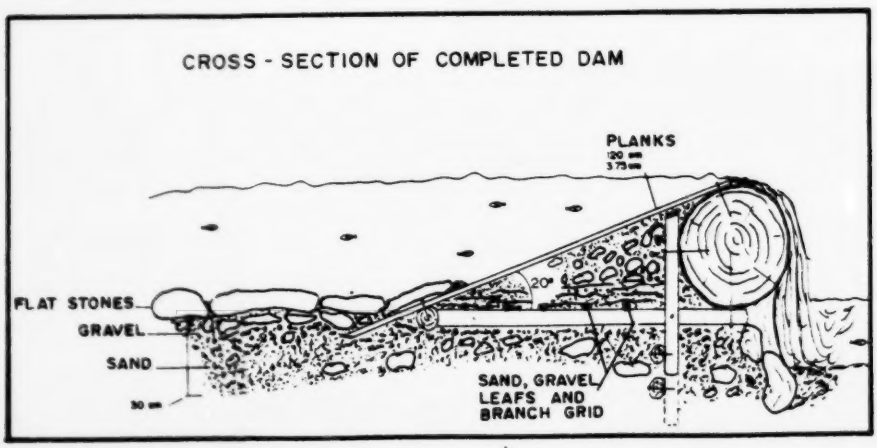
In this case we can procede in the same manner as in the previously described method, but we must adapt the spillway to a single-log plank dam.

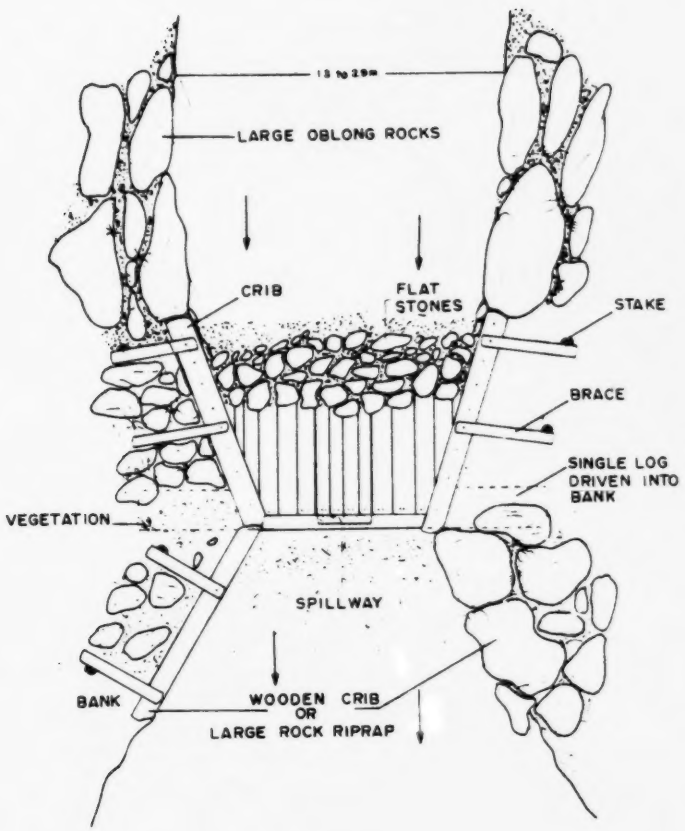




Completed dam





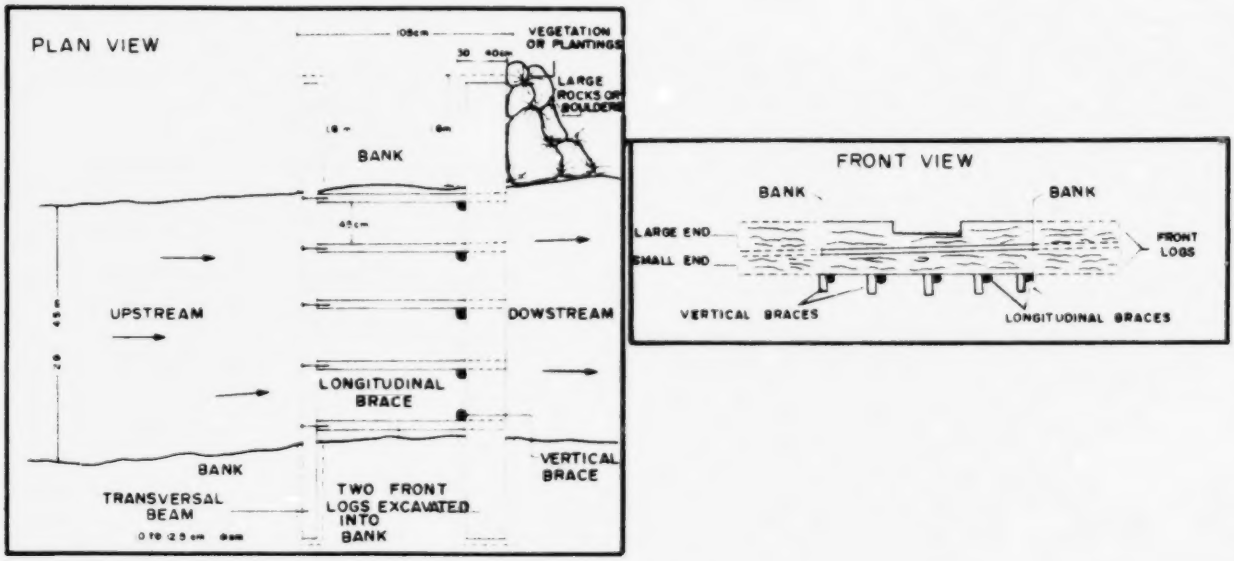


PLAN VIEW OF COMPLETED SINGLE-LOG DAM

C- TWO-LOG DAM WITH UPSTREAM GRAVEL FILL
(ADAPTED VERSION OF THE TWO-LOG PLANK DAM)

For streams 2.9 m to 4.5 m in width (9.5 to 15 ft) having minor flow variations, we suggest building a two-log dam with upstream gravel fill.

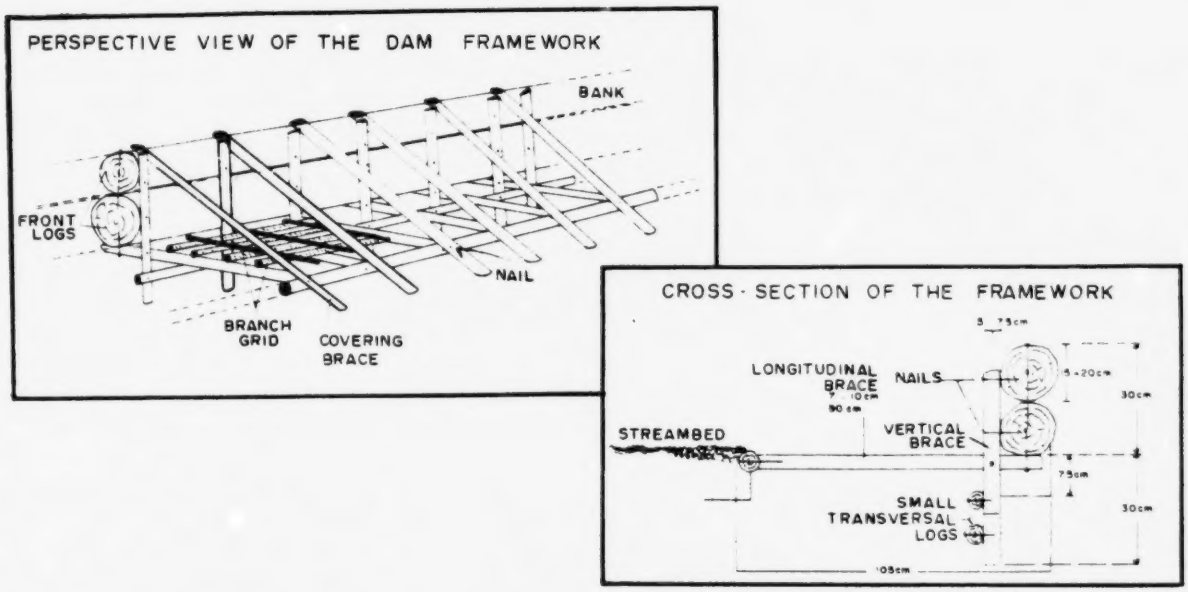
First step: levelling the streambed and excavating the banks



Prepare the streambed where the dam will be built; i.e. levelling, enrockment over a width of 105 cm (42 in.) without causing a major disturbance to the environment.

At the upstream and downstream limits of the prepared section the banks are excavated horizontally over a width of 30 to 40 cm (12 to 16 in.) and to a depth of 1.6 m (5 ft.).

Second step: the supporting framework



At the upstream limit of the levelled section a transversal beam 10 to 12.5 cm (4 to 5 in.) in diameter is lodged into the bed and the banks at the locations indicated.

Parallel longitudinal braces (in the direction of the current) 7 to 10 cm (3 to 4 in.) in diameter and 90 cm (36 in.) in length are supported against and nailed perpendicularly to the downstream side of the transversal beam. These braces are spaced 45 cm (18 in.) apart center to center.

Two coniferous logs 15 to 20 cm (6 to 8 in.) in diameter are placed on the downstream end of the parallel longitudinal braces. The former are piled one on top of the other with the small end on top of the large end and are driven 1.6 m (5 ft.) into the banks at the designated locations. These logs are held in place by 25 to 30 cm (10 to 12 in.) spikes.

On the upstream side on the dam, pieces of coniferous wood 5 to 7.5 cm (2 to 3 in.) in diameter are attached or nailed vertically to the two logs and are spaced 45 cm (18 in.). At the top end each of these pieces

of wood should not extend beyond the centre of the upper log where they are nailed. At the bottom end these pieces of wood should exceed the bottom log by at least 7.5 cm (3 in.). These braces are also nailed to the centre of the lower log and laterally (on the side) to the parallel longitudinal braces.

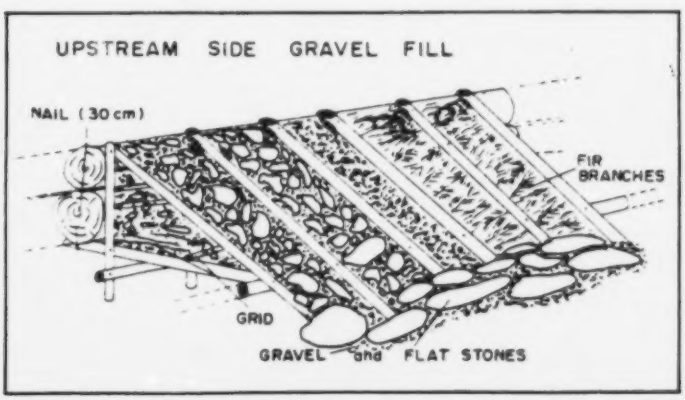
The vertical braces may even exceed the bottom of the lower log by 30 cm (12 in.); on the upstream side one or two small transversal logs may be nailed to these vertical braces.

This last section of the framework is not absolutely necessary but may in certain cases help keep the materials on which the framework is supported in place for a longer period.

Tree and shrub branches approximately 2.5 cm (1 in.) in diameter are attached to the structure formed by the parallel longitudinal braces and the transversal beam. Fir branches are placed on top of these branches and also fixed to the two superposed front logs (facing upstream).

This operation forms a grid which lasts much longer than a metal grid, the latter only lasting around two years.

Third step: filling the upstream side of the dam



Once the grid is in place the space between the grid and the top of the second log is filled with gravel and stones. This operation is carried out on the basis of a 20° angle.

Pieces of wood 5 to 7 cm (2 to 3 in.) in diameter are then placed in parallel over the gravel and are spaced 45 cm (18 in.) apart. The top ends of covering braces are attached to the surface of the second log, while the bottom ends are nailed to and extend beyond the transversal beam by at least 20 cm (8 in.).

The presence of covering braces on top of the gravel will facilitate ice movement over the dam and reduce risks of damage during the spring flood period.

A final operation consists in placing fir branches between the gravel and the covering braces; these branches are also covered with gravel and stones (especially); this layer should be a few centimetres (5 to 6 in.) thick.

The fir branches covering the gravel will help maintain the latter in place during flood periods and limit any damage.

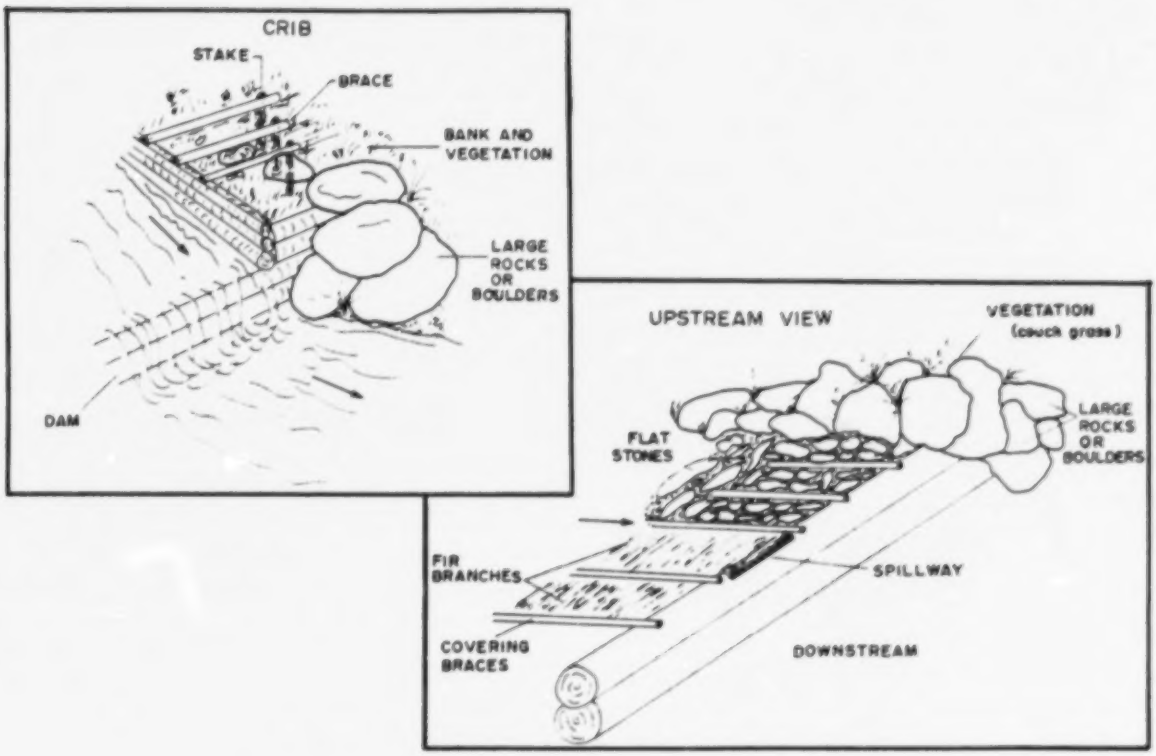
The transversal beam must also be covered with a layer of gravel and stones at least 12.5 to 15 cm (5 to 6 in.) thick.

Forth step: protecting the bank at each end

Large flat or oblong stones should be placed over a length of around 1.6 m (5 ft.) along the banks upstream and downstream of the dam ends. The pile of rocks should be at least as high as the spring flood water line. Gravel, sand, dirt, clumps of grass and couch grass are placed between the rocks as well as any other plant that will take root and grow

quickly.

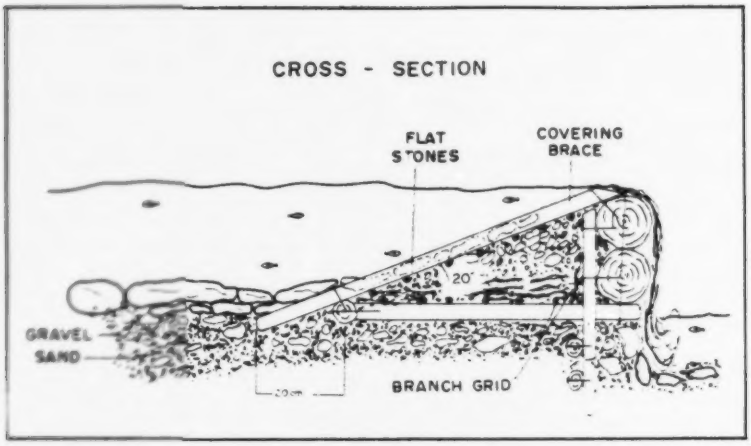
Cribs may also be built at the dam ends according to the method described for the two-log plank dam. This option may prove preferable.

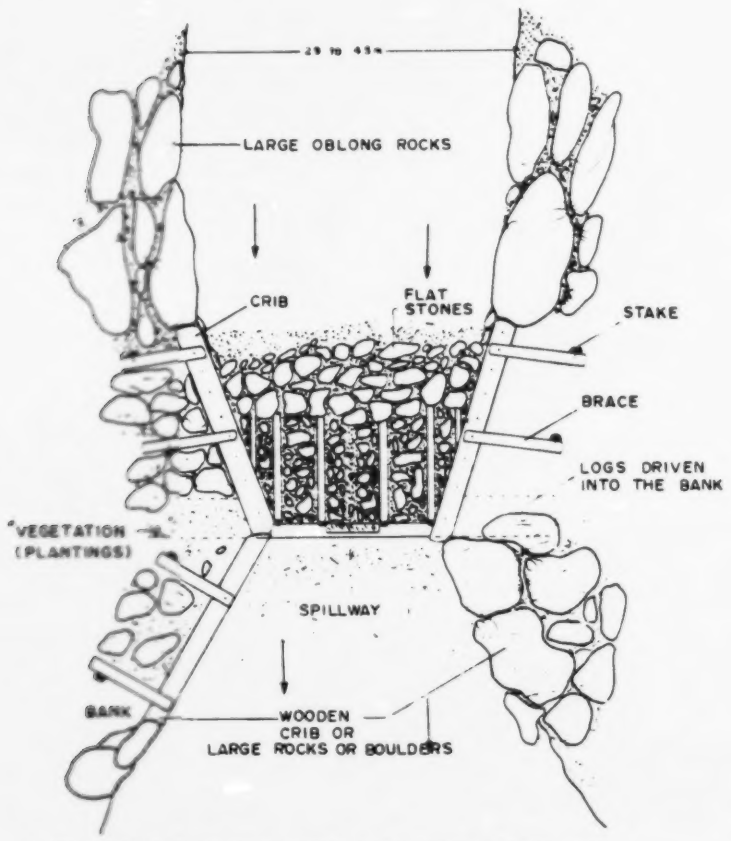


Fifth step: a spillway

See the two illustrations of the last step of the previous technique. If the low-water periods are long and severe, it may be useful to plan for a spillway on the dam. A horizontal groove 3.75 cm (1.5 in.) in height and 45 cm (18 in.) in width is made in the middle of the dam. This groove should not be made deeper than the top of the layer of stones and gravel.

Completed dam



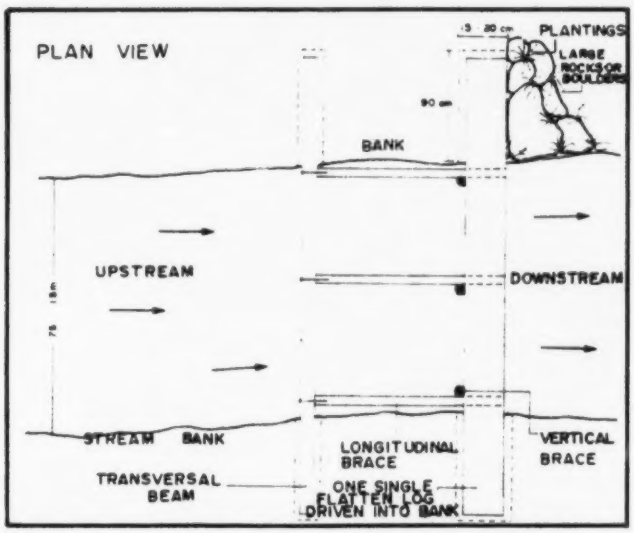


PLAN VIEW OF THE TWO LOG DAM WITH AN UPSTREAM GRAVEL FILL

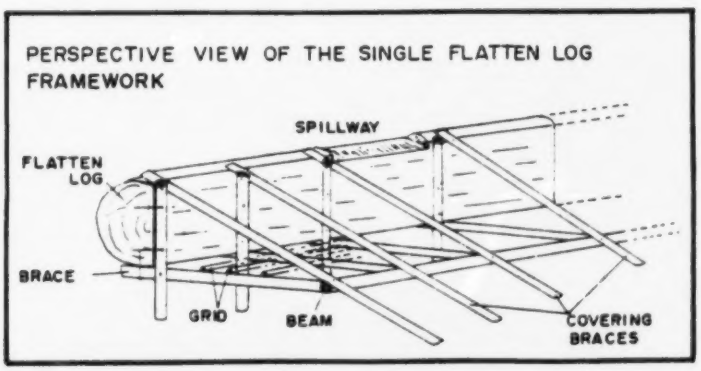
D- FOURTH TYPE OF DAM: SINGLE FLATTEN LOG DAM WITH SUPPORTING FRAME-WORK

The dam construction method that we just described may also be applied to smaller streams measuring between approximately 2 and 2.7 m (6 to 9 ft.) in width. However, the banks would have to be steep and very high. It would be necessary to have two logs 10 cm (4in.) in diameter to build the dam (one on top of the other) or a single log 20 cm (8 in.) in diameter, one third or two fifths of the diameter of which would have been removed beforehand in order to have flatten surface on the upstream side.

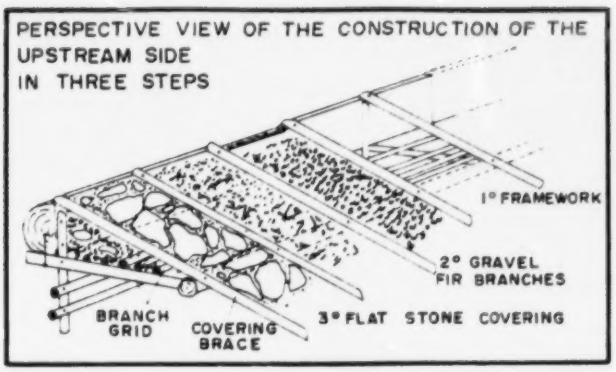
First step



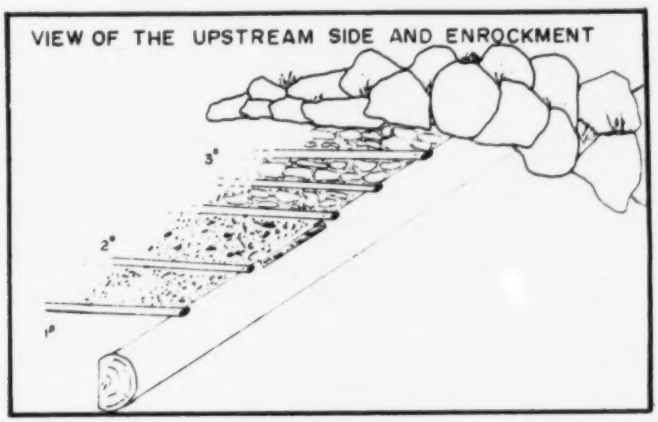
Second step

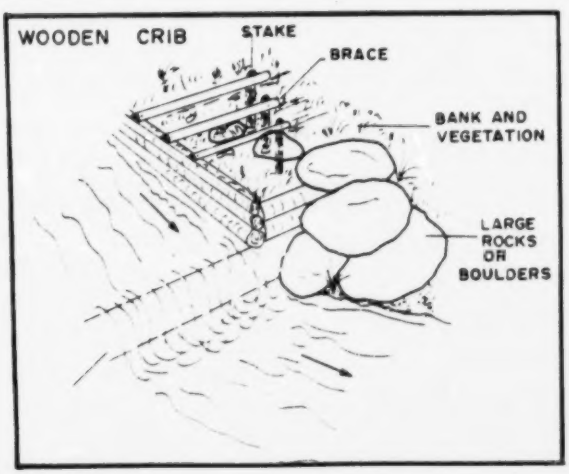


THIRD STEP



Fourth step

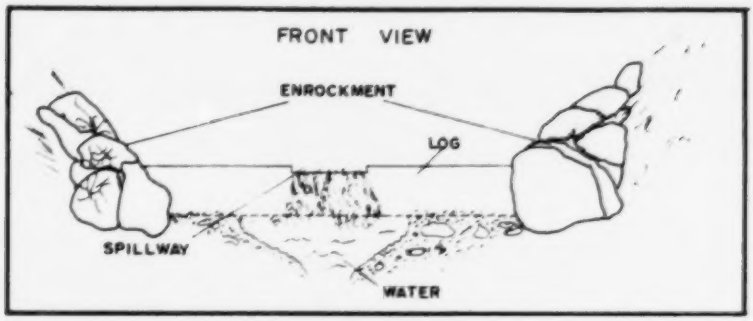


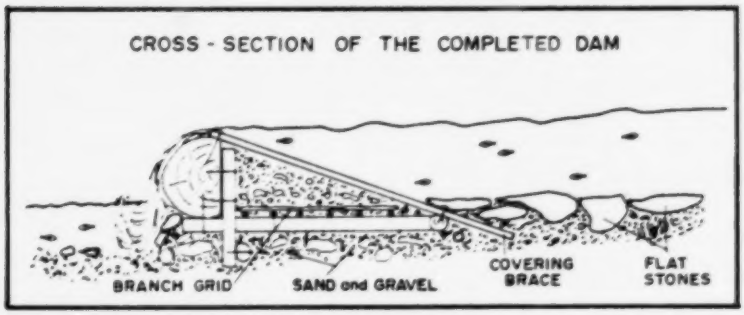


Fifth step

See the illustrations of the second, third and fourth steps as well as the last two of this series.

The advantage of this dam construction method is that it enables us to find and use all the materials located in the area.

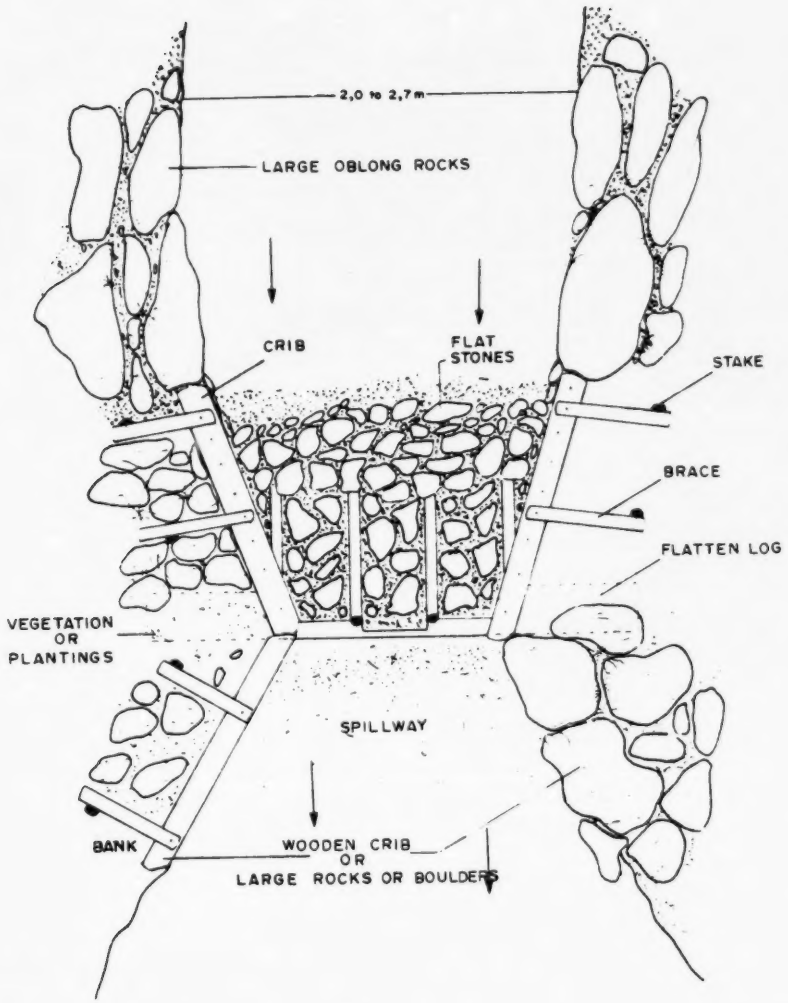




E- SINGLE FLATTEN LOG DAM WITH ORDINARY GRAVEL FILL (VERY SMALL STREAMS)

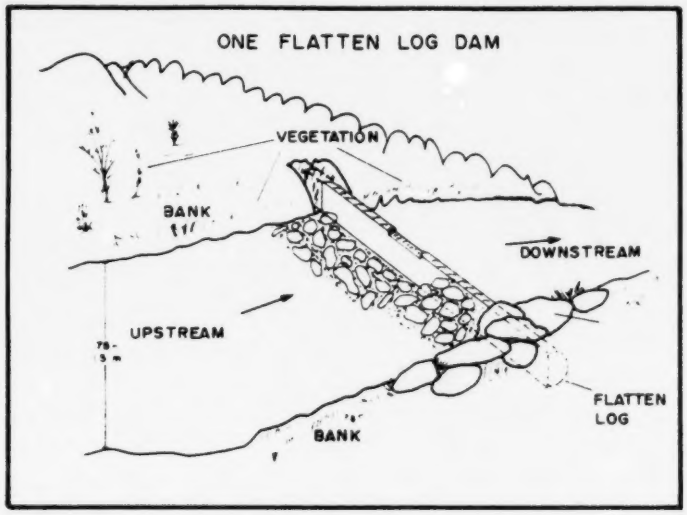
Pools may be dug in order to "concentrate" fish or either to create spawning sites in these pools.

In very small brooks 0.75 to 1.5 m (2.5 to 5 ft.) in width where there is generally little water flow and a very gradual slope, we can try to combine both pools and spawning sites by using dams made of a single log and gravel.



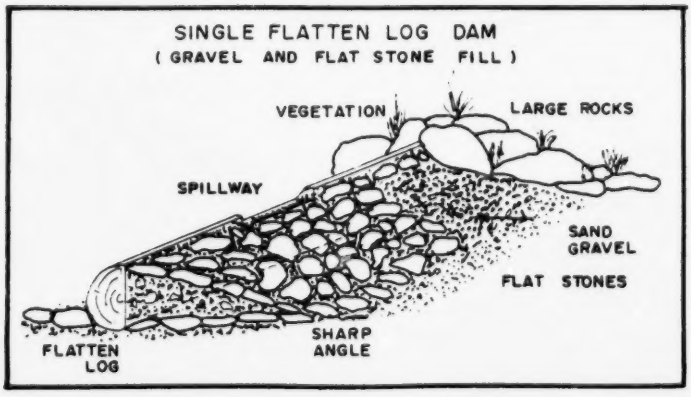
PLAN VIEW OF A COMPLETED SINGLE FLATTEN LOG DAM

To do so, we must use logs 15 to 20 cm (6 to 8 in.) in diameter embedded 5 to 7.5 cm (2 to 3 in.) in the streambed and driven 90 cm (36 in.) in the banks. Using an axe or a saw it is necessary to remove one third or two fifths of the width of these logs beforehand in order to make a perfectly flat surface on the upstream side.

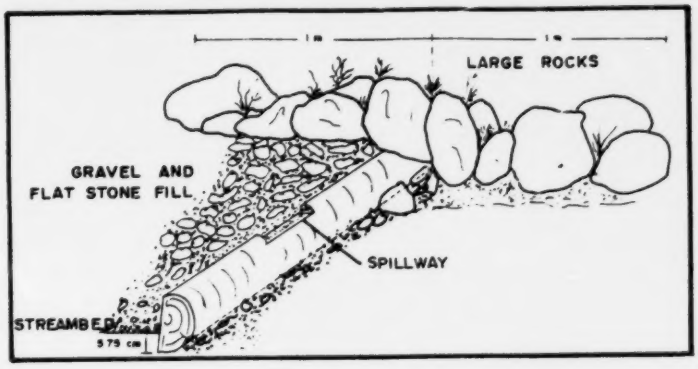


At the centre of these logs we then cut a spillway 2.5 to 3.75 cm (1 to 1.5 in.) in depth and 20 to 40 cm (8 to 16 in.) in width according to the length of the dams.

Gravel is placed on the upstream side of the logs, forming a gradual slope up to the level of the spillway.

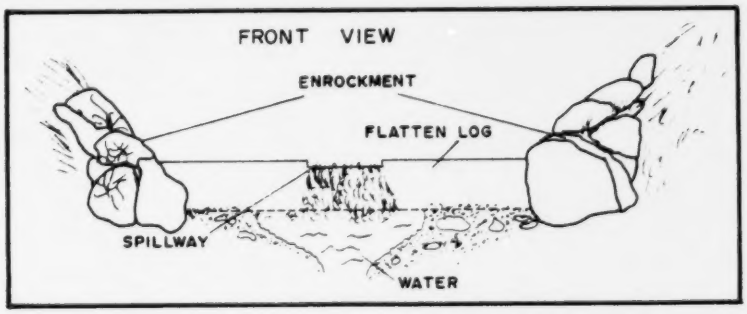


Upstream and downstream of the ends of each dam rocks will have to be placed over a length of 1 m (38 in.). The height of the enrockment will have to be equal to that of the flood water line.



This type of dam can be placed every 22 metres in the chosen section.

This dams will help dig small pools which will enable fish to circulate from one pool to another easily.



A particular section of the brook may also be chosen where such dams would be placed only 9 m (30 ft.) apart in order to deposit more gravel at the appropriate locations. This distance should represent approximately five (5) to seven (7) times the width of the brook.

This type of dam may also be built at the mouth of a small farmpond affluent to create a water intake, turbulence or to improve water oxygenation.

In brooks 1.5 m (5 ft.) in width the same method of construction could be used with a supporting framework and rock and gravel fill.

CONCLUSION

The basic principle that must be respected in the application of the methods and techniques we have described in this booklet is the creation and preservation of conditions which favour the survival, growth and reproduction of fish in upgraded streams.

We feel that the dam construction techniques described in this booklet will be of tremendous help in applying the above-mentioned principle.

The techniques that we have described may be used both by interested groups who have received proper councelling from qualified experts.

We have attempted to adapt and describe methods and techniques which will offer the best resistance to environmental conditions such as spring and autums floods.

By using materials in or around the area, we can keep construction costs relatively low and are at the same time better able to respect the natural setting.

Suggestions

We should now like to make a few suggestions concerning the type of tools or equipment that may be used to carry out the various stream improvement projects:

- Cables
- Chains
- Nails
- Log hooks
- Pruners
- Axes
- Metal lever
- Hammer

- 3 to 4 kg sledge-hammer
- Round-end shovel
- Pick
- Chain saw
- Gauge saw
- 700 to 1 000 kg capacity hoist

GLOSSARY (DEFINITION OF TERMS)

Access infrastructure:	Place or facility giving or facilitating access to a stream or permitting the participation in a given activity, e.g. parking lot, wharf, quay or landing platform, etc...
Algae:	Common name for a large number of common aquatic plants having neither roots, leaves, nor seeds and which are found in both fresh and salt water in a varying degree according to the quality of the environment (green moss). These are usually microscopic plants to which we are refering in this document.
Bank:	Edge of a stream visible during low water periods.
Beam:	Large piece of wood which supports, connects or reinforces several other pieces.
Bed:	Channel hollowed out by a stream or place where the latter flows during low flow periods.
Behaviour (stream):	Manner of reacting, altering or changing its aspect, form or flow.
Brushwood:	Section of wooded area or forest where there are only small trees stemming from stubs or suckers.
Dam/sill:	Series of rocks or pieces of wood lying across a stream and supporting a floor made of various materials.
Dike:	Small layer of rocks arranged acros a stream bed to create a small waterfall.
Dowstream:	In the direction of the current.
Environment:	Entire group of factors likely to have an effect on living organisms and the activities of man.
Eroded:	Worn away under the action of water or ice.
Erosion:	Wearing away of a stream bed or banks through the flow of water, ice or any other materials.
Expertise:	Assessment or evaluation of a problem, project or situation by a person having among other things a great deal of technical knowledge.
Flatten:	To make a surface flat.
Flood:	Swelling of a stream following heavy rain or the melting of snow.
Floor:	Flat surface which may be made of various materials and which constitutes the upstream section of a completed dam.

Food chain: A complex process in which the various living organisms of an environment or a habitat feed on one another in order to obtain energy, survive or perpetuate the species.

Grid: A group of intertwined branches, pieces of wood or metal wires.

Horizontally: Arranged in a position which is parallel to the horizon.

Longitudinal braces: Pieces of wood lying across the dam in the direction of the current (bordering the current).

Meander: Winding, convolution or crisscrossing of a stream.

Mortised: To cut a hole or a notch in a piece of wood which will be attached to another piece of wood.

Objective: Recommended means or orientation for attaining a given goal.

Parallel braces: Several pieces of wood lying crosswise to another piece and arranged one beside another in the same direction.

Perpendicularly: Arranged on a 90° angle in relation to another line, object or piece.

Pool: A naturally or artificially made depression or hole in a stream normally located where the average depth of the water is much greater than in other locations and where the current is slower.

Restoration: Operation which aims at giving back the initial appearance to a given place or at restoring proper order through the reconstitution of certain sections.

Riparian vegetation: Vegetation which grows on the banks alongside a stream or a lake.

Rustic: Rough or plain: ressembling plants or materials found in a natural environment.

Seal: To plug or fill in spaces or holes.

Shelter or cover: Place where an animal can go and hide to rest or protect itself from hostile environmental conditions.

Spawning site: Part or section of a stream or place where fish spawn or reproduce.

Spillway: Groove made on the top of a dam or a sill to concentrate waterflow especially during low water periods.

Steep: State of a thing, object, piece of land or rock whose slope is very abrupt or sheer.

Support: Way or manner of supporting a structure or work project.

Transversally:	Which crosses an object, space, construction or structure perpendicularly (on a 90° angle) either lengthwise or heightwise depending on which dimension is larger.
Turbulence:	Irregular motion or swirling agitation of water at the base of a small dam or sill.
Upstream:	In the direction of the stream's source.
Vertically:	To place in the same direction as a plumbline; i.e. perpendicularly to an object, plane or horizontal surface.
Vital space or territory:	Combination of essential or restrictive factors or sub-factors (environmental conditions) which constitute the space required for the survival, preservation and development of the species.

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